



Modeling and Simulation of a System of Systems: Incorporating Electromagnetic and Radiation Effects into the Army's Future Combat Systems

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29 March 2007



Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE MAR 2007		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Modeling and Simulation of a System of Systems: Incorporating Electromagnetic and Radiation Effects into the Armys Future Combat Systems				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) L-3 Communications-Jaycor				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM202664. Advanced Development of Unified Electromagnetic (EM) Design Software Capability, The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 16	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



Acknowledgments

- WSMR/SVAD
 - John O’kuma, Mike Thurston, Micaela Nevarez, and Marty Fritz
- FCS
 - Ed Dunlap and Jerry Wightman
- ATEC
 - Paul Kelley and Donna Smoot
- DTRA/NTES
 - Dexter Simmons (THTk) and Randy Davis (UEM)
- L-3 Communications – Jaycor (NETS/THTk)
 - Jonathan Morrow-Jones, Dennis Krueger, and Landon Rabern
- BGC (DETES/UEM)
 - Bob Gray and Paul Dykstra (Merlin Simulation)
- TRAC-WSMR
 - Barbara Dixon
- Strategic Analysis
 - Lindsay Samora, Scott Klakken, Stephen Hunia, and Doug Drake



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Background

- Army's Future Combat Systems (FCS)
 - FCS operates as a system-of-systems
 - Whole greater than sum of parts
- Net-centric
 - Enables soldiers to perceive, comprehend, shape, and dominate the future battlefield
 - Network provides the synergistic glue for FCS
 - Performance not dependent on single element, but on success of the system-of-systems (SoS)



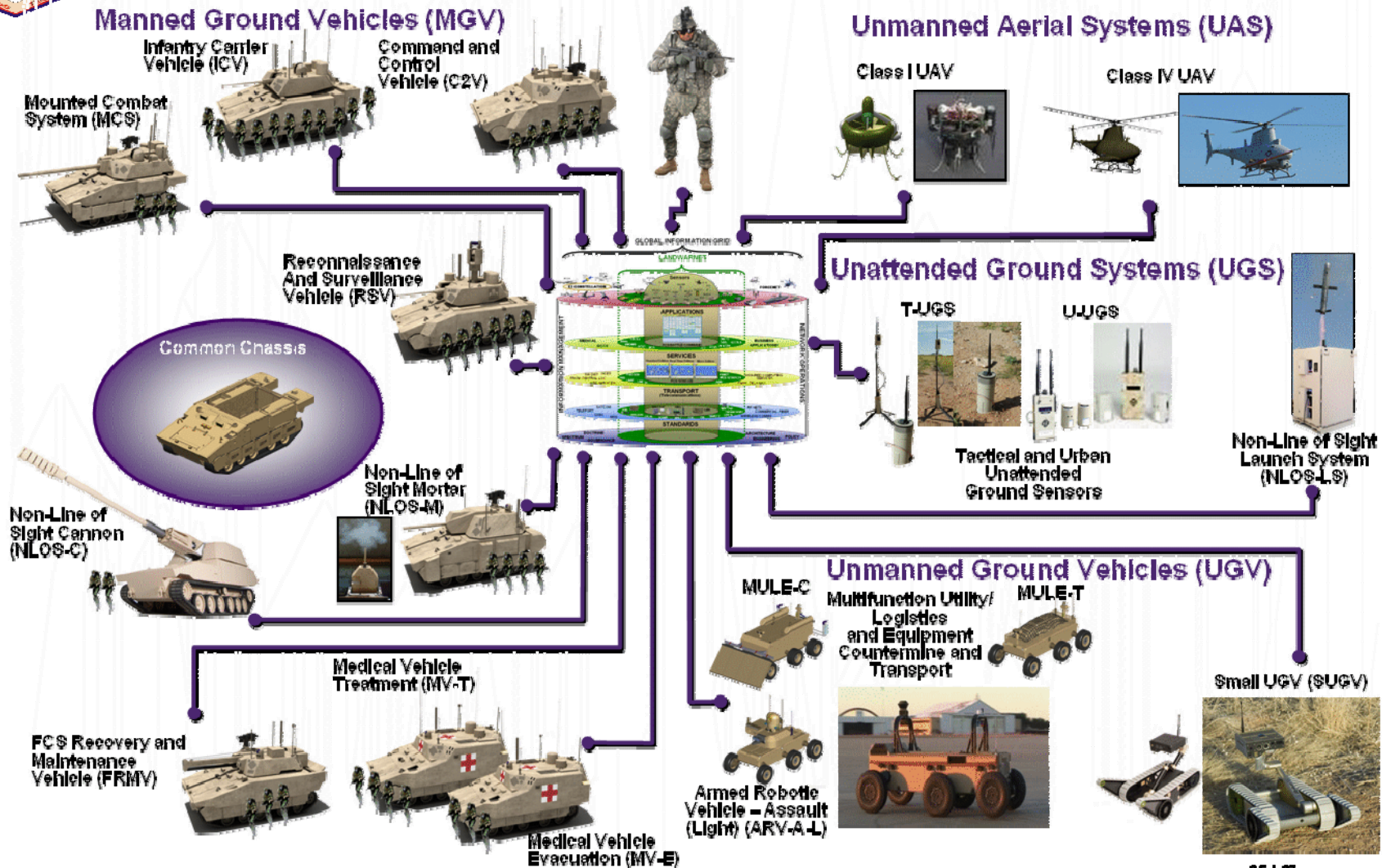
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FCS Brigade Combat Team...



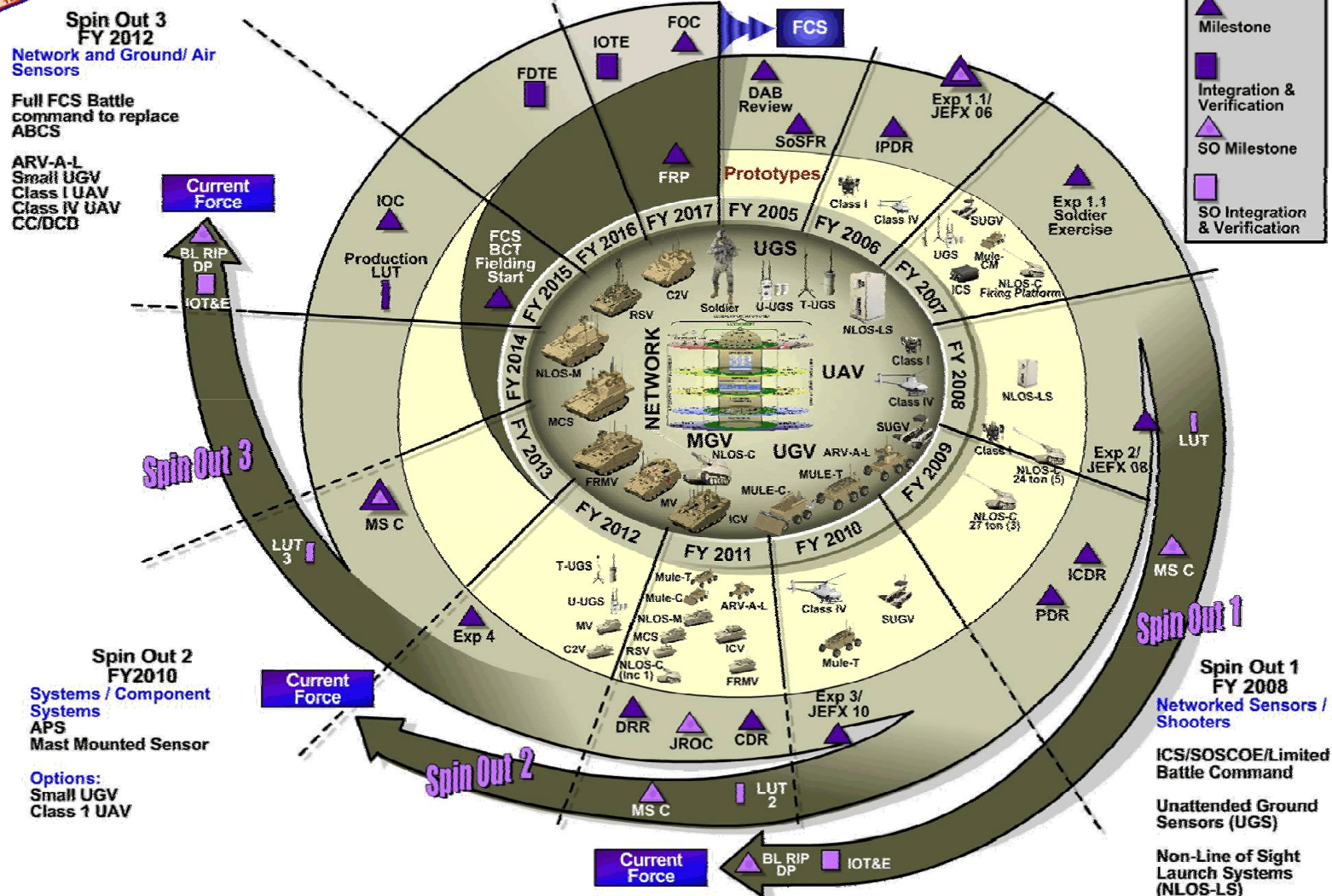
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FCS (BCT) System-of-Systems Schedule



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System-of-Systems Qualification

- Challenge
 - Performance measured at SoS level
 - Can SoS complete mission?
 - Many new platforms
 - Platforms developed in parallel
 - Platforms must work together
- Solution
 - Rely on wargaming
 - Mix live elements with simulated battlefield and weapon effects
 - Modeling and simulation V&V'd
 - Models tethered to data



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NETS and DETES

- Nuclear Effects Threat Simulator (NETS)
 - Models effects from ground and near ground bursts
 - Gammas, neutrons, overpressure,...
 - Two main components
 - Platform model: *Testable Hardware Toolkit (THTk)*
 - Real-time wargame simulation: *SurVNETS*
- Directed Energy Threat Environment Simulator (DETES)
 - Models EM environment effects
 - HEMP, HPM, lightning,...
 - Two components
 - Platform model: *Unified Electromagnetic Design (UEM)*
 - Real-time wargame simulation: *DETES*



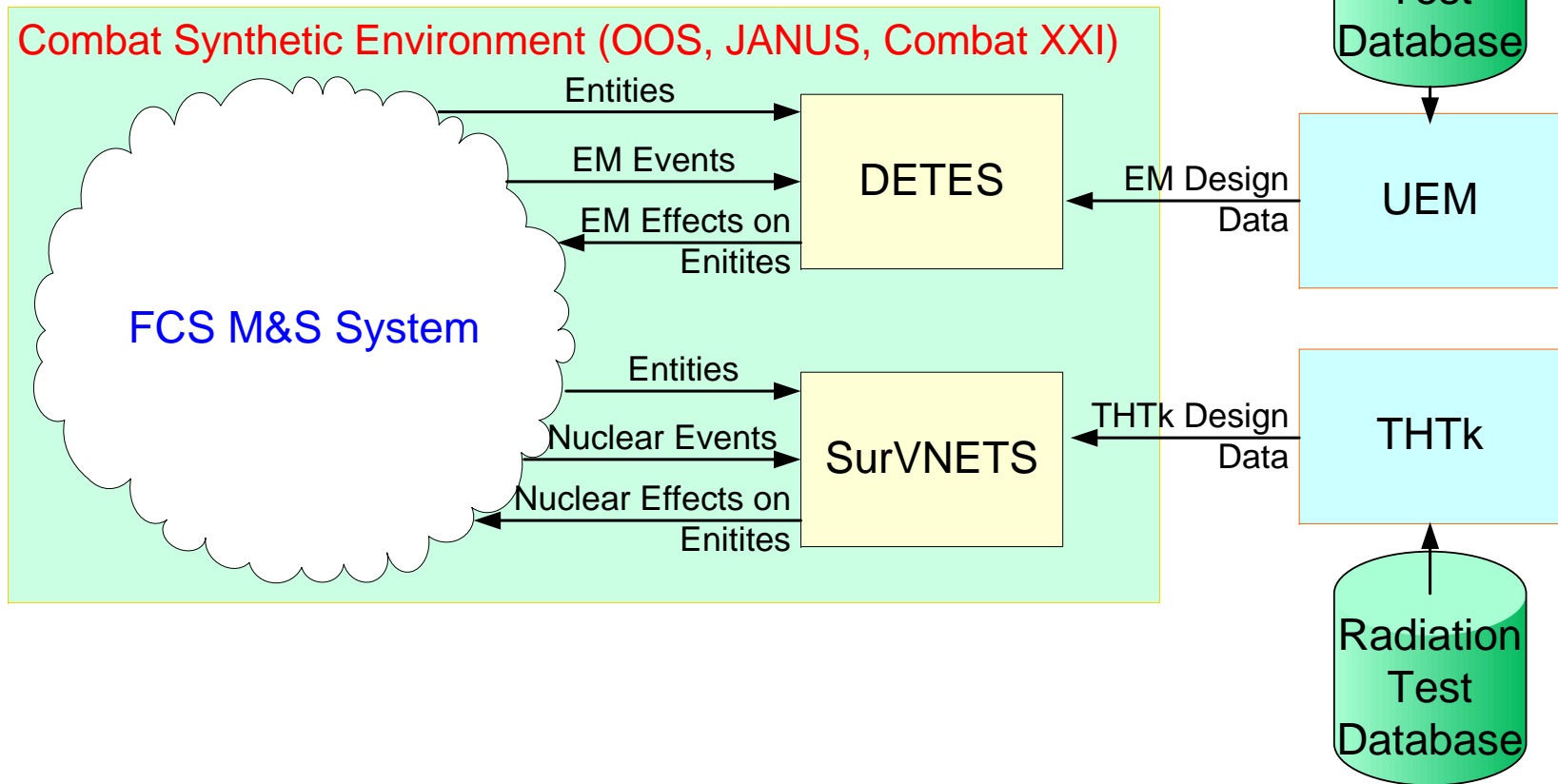
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NETS / DETES Operational Diagram





NETS

- NETS Tools
 - Build platform models with *THTk Workbook*
 - *SurVNETS* operates in near real-time Combat Synthetic Environment
- SurVNETS
 - Effects threshold data
 - High-speed nuclear environments
 - Conveys functional impact on all battlefield entities to combat synthetic environment



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NETS: Effects Thresholds

SurVNETS Properties Editor

File Edit Help

All Categories

- Other
- Platform
 - Other
 - Land
 - Air
 - Other
 - Fighter/Air Defense
 - Attack/Strike
 - Bomber
 - Cargo/Tanker
 - ASW/Patrol/Observation
 - Electronic Warfare (EW)
 - Reconnaissance
 - Surveillance/C2 (Airborne Early Warning)
 - Attack Helicopter
 - Utility Helicopter
 - Antisubmarine Warfare/Patrol Helicopter
 - Cargo Helicopter
 - Observation Helicopter
 - Special Operations Helicopter
 - Trainer
 - Unmanned
 - Non-Combatant Commercial Aircraft
- Surface
- Subsurface
- Space
 - Other
 - Manned
 - Unmanned
 - Booster
- Munition
- Life form
- Environmental
- Cultural feature
- Supply

Air

☐ Inherit from parent

Susceptibility Properties

Overpressure:

Mobility Threshold: 1.5

Firepower Threshold: 1.5

Destroyed Threshold: 3

Reference: JMJ estimates

Gamma Dose Rate:

Mobility Threshold: 1000000000

Firepower Threshold: 100000000

Destroyed Threshold: 10000000000

Reference: JMJ estimates

Gamma Dose:

Mobility Threshold: 10000

Firepower Threshold: 10000

Destroyed Threshold: 100000

Reference: JMJ estimates

Display Properties

Image File: GenericAirPlatform.png



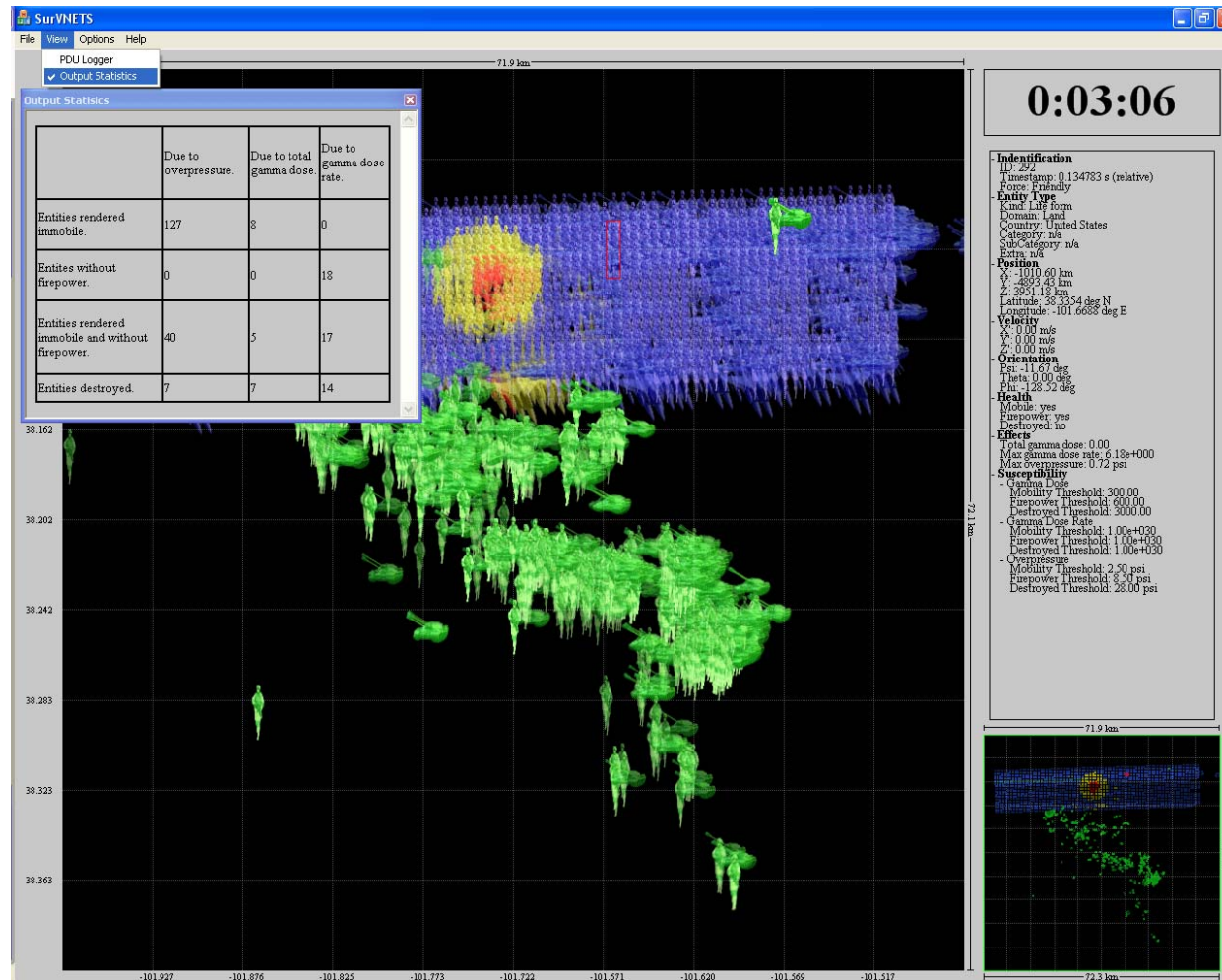
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NETS Tools: SurVNETS Interface



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DETES

- DETES Tools
 - Build platform models with *UEM Design*
 - *DETES* operates in near real-time Combat Synthetic Environment
- *DETES*
 - Probability of effect models
 - High-speed EM environments
 - Conveys functional impact on all battlefield entities to combat synthetic environment



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DETES User Interface

Exercise Runtime Mode

DETES Version 1.0 Main Control Form

Setup UDP
 ☒ Byte Swap Received Data ☒ Byte Swap Send Data

Remote Host: 255.255.255.255 Receive Port: 3000 Send Port: 3000

Data Base
 Path and Name: C:\Documents and Settings\All Users\Documents\DETES Phase 2\Version 1.0\Version 1 w new db\Test Data Bases\DETES Da

DETES Processing

Entity State
 Janus Site: 1
 Janus Host or Application: 1

Global Entity State
☒ Static ☐ Learn

Fire
☐ Log Fire PDUs

Nuclear Effects
☒ Do Statistical Upset/Damage
☒ Log Nuclear Effects PDUs
☐ Send Nuclear Effects PDUs

PDU Rate:

Detonation
☐ Log DETES Detonation PDUs
☐ Log all Detonation PDUs

HEMP HOB
☒ Detonation PDU ☐ HEMP Form

Global Detonation
☒ Static ☐ Learn

Environment Parameters
☒ Static (Forms) ☐ Dynamic (PDU/Data Base)

PDU Status

Number of PDUs:

PDUs Received: 1
 # PDUs Not Processed: 0

☐ Display Next PDU

Protocol Version 5
 Exercise Identifier 1
 PDU Type 1
 Protocol Family 1
 Time Stamp 0
 PDU Length 104
 Site 1
 Host 1
 Entity 1
 Force ID 225

Self Test

Entity State
☒ Single PDU PDU Rate:
☐ Multiple PDUs

Repeat #:

Detonation - Extra (Byte80)
☐ HEMP ☐ HPM ☒ Static

Nuclear Effects

HPM Environment

Source

Power (MW): 10.0 Frequency (GHz): 5.0
 Antenna Aperture (m²): 10.0

Environment

Peak Field @ 1 m (V/m): 4576510.07258 Maximum Range (m): 4576.51007
 Upset Threshold (V/m): 1000

HEMP Environment

Weapon Information

Height of Burst (50 to 400 km): 50
 Gamma Ray Yield (0.001 to 10.0 KT): 10.0

Earth

Radius (km): 6370.062326
 Tangent (km): 6419.8676208878

HEMP Environment Levels

28.951739335457 13.386248510651
 Maximum Field (kV/m) Tangent Field (kV/m)

Scaling

0.15888397834 50 28.9517393354579

Scaling Exponent Range (km) Environment (kV/m)



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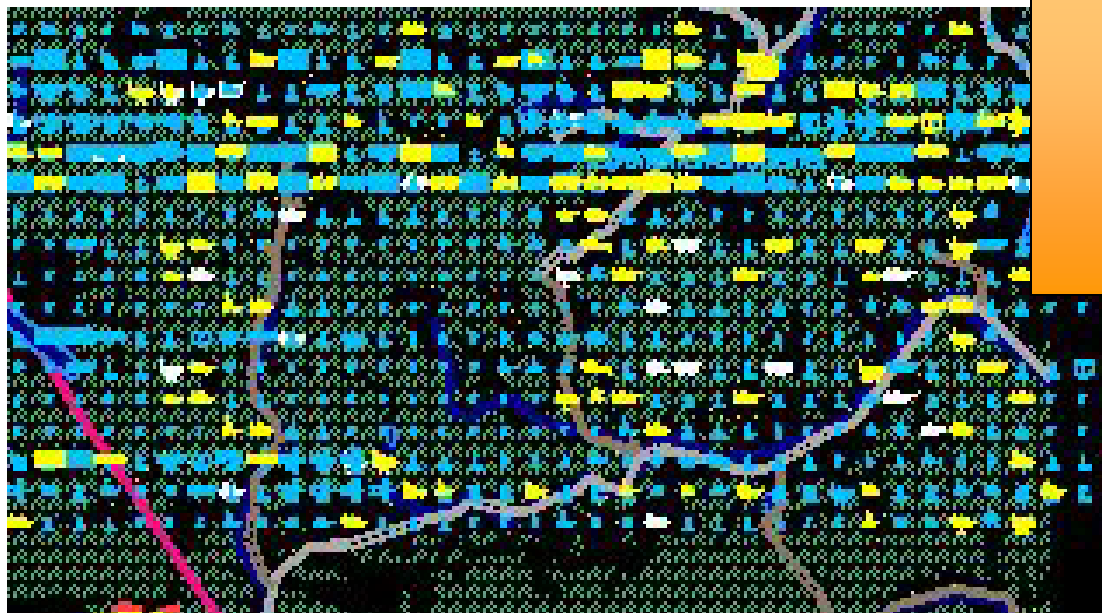
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EM Effects Results for a Hypothetical HEMP Event

- Hardness levels arbitrarily set by type of equipment
- 5,624 entities processed for upset and damage effects
- Percentages consistent with P_e for each class



Color Code:
No Effect
Upset
Damaged



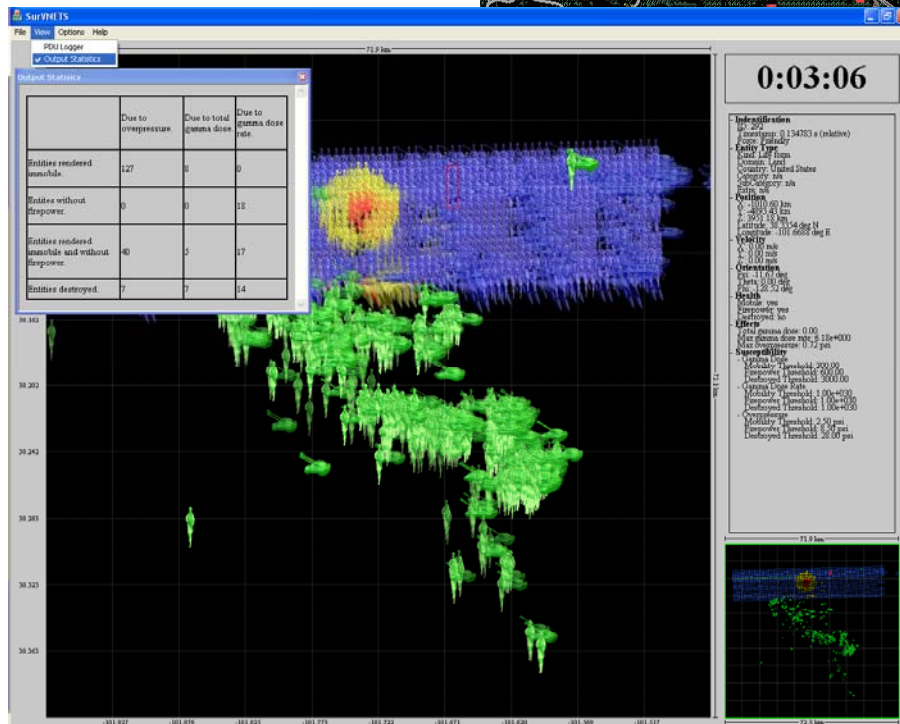
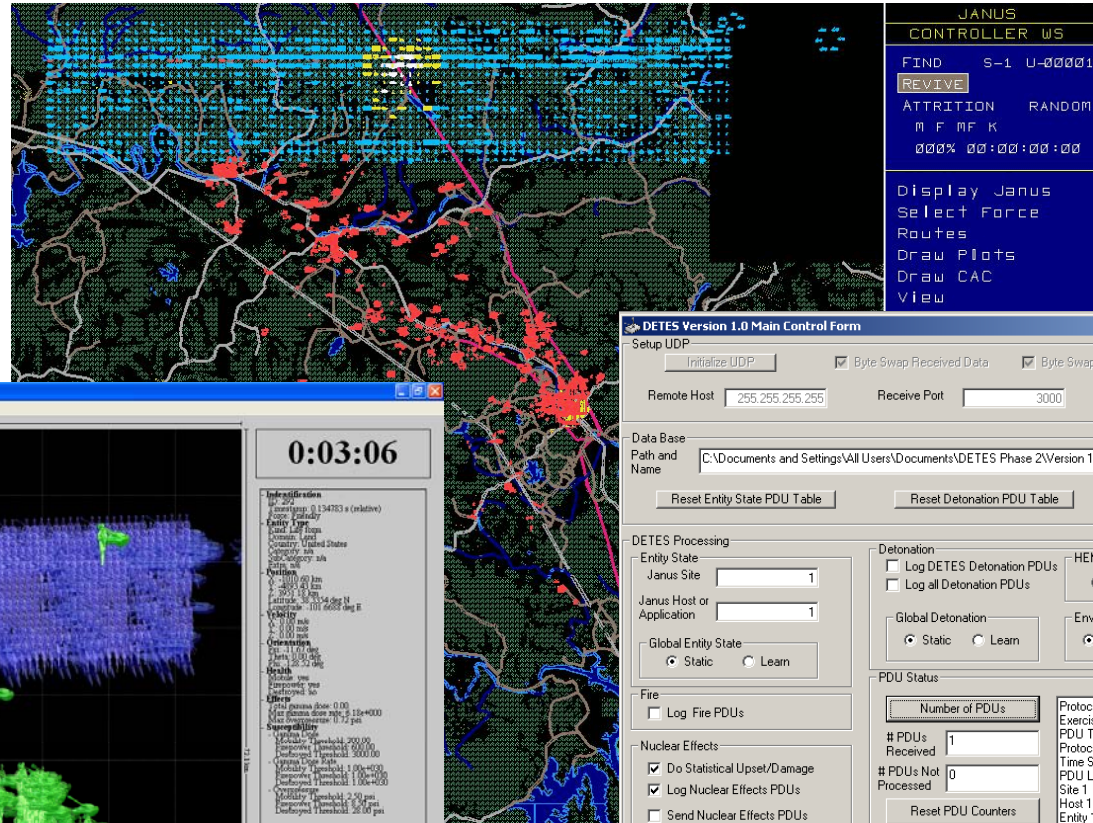
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JANUS Battlefield Simulation



DETES Version 1.0 Main Control Form

Setup UDP

Initialize UDP ☒ Byte Swap Received Data ☒ Byte Swap Send Data Disconnect UDP

Remote Host: 255.255.255.255 Receive Port: 3000 Send Port: 3000

Data Base Path and Name: C:\Documents and Settings\All Users\Documents\DETES Phase 2\Version 1.0\Version 1 w new db\Test Data Bases\DETES Da

Reset Entity State PDU Table Reset Detonation PDU Table Reset Nuclear Effects PDU Table

DETES Processing

Entity State: Janus Site 1

Janus Host or Application: 1

Global Entity State: Static Learn

Fire: ☐ Log Fire PDUs

Nuclear Effects: ☒ Do Statistical Upset/Damage ☒ Log Nuclear Effects PDUs ☐ Send Nuclear Effects PDUs

PDU Rate: 0.000

Detonation

☐ Log DETES Detonation PDUs ☐ Log all Detonation PDUs

HEMP HOB

☒ Detonation PDU ☐ HEMP Form

Global Detonation

☒ Static ☐ Learn

Environment Parameters

☒ Static (Forms) ☐ Dynamic (PDU/Data Base)

PDU Status

Number of PDUs: 1

PDUs Received: 1

PDUs Not Processed: 0

Reset PDU Counters

☐ Display Next PDU

Protocol Version 5

Exercise Identifier 1

PDU Type 1

Protocol Family 1

Time Stamp 0

PDU Length 104

Site 1

Host 1

Entity 1

Force ID 225

Self Test

Entity State: Single PDU PDU Rate: 0.000

Repeat #: 1

Send Entity State PDU

Detonation - Extra (Byte80)

☐ HEMP ☐ HPM ☒ Static

Send Detonation PDU

Nuclear Effects

Send Nuclear Effects PDU



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Conclusion

- NETS and DETES Version 1.0 development complete
- Software development included Verification and Validation
- Capability demonstration with *JANUS*
- Future development will include interface with other M&S applications



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